ANALOG DEVICES

1 pC Charge Injection, 100 pA Leakage, CMOS ± 5 V/+5 V/+3 V Quad SPST Switches

ADG611/ADG612/ADG613

FUNCTIONAL BLOCK DIAGRAMS

FEATURES

1 pC Charge Injection ±2.7 V to ±5.5 V Dual Supply +2.7 V to +5.5 V Single Supply Automotive Temperature Range -40°C to +125°C 100 pA Max @ 25°C Leakage Currents 85 Ω On-Resistance Rail-to-Rail Switching Operation Fast Switching Times 16-Lead TSSOP Packages Typical Power Consumption (<0.1 μW) TTL/CMOS-Compatible Inputs

APPLICATIONS

Automatic Test Equipment Data Acquisition Systems Battery-Powered Systems Communication Systems Sample and Hold Systems Audio Signal Routing Relay Replacement Avionics

GENERAL DESCRIPTION

The ADG611, ADG612, and ADG613 are monolithic CMOS devices containing four independently selectable switches. These switches offer ultralow charge injection of 1 pC over full input signal range and typical leakage currents of 10 pA at 25°C.

They are fully specified for ± 5 V, ± 5 V, and ± 3 V supplies. They contain four independent single-pole/single-throw (SPST) switches. The ADG611 and ADG612 differ only in that the digital control logic is inverted. The ADG611 switches are turned on with a logic low on the appropriate control input, while a logic high is required to turn on the switches of the ADG612. The ADG613 contains two switches whose digital control logic is similar to the ADG611, while the logic is inverted on the other two switches.

Each switch conducts equally well in both directions when ON and has an input signal range that extends to the supplies. The ADG613 exhibits break-before-make switching action. The ADG611/ADG612/ADG613 are available in small 16-lead TSSOP packages.

PRODUCT HIGHLIGHTS

- 1. Ultralow Charge Injection (1 pC typically)
- 2. Dual ±2.7 V to ±5.5 V or Single +2.7 V to +5.5 V Operation.
- 3. Automotive Temperature Range, -40°C to +125°C
- 4. Small 16-lead TSSOP package.

REV.0

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One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A. Tel: 781/329-4700 www.analog.com Fax: 781/326-8703 © Analog Devices, Inc., 2002



SWITCHES SHOWN FOR A LOGIC "1" INPUT

ADG611/ADG612/ADG613-SPECIFICATIONS

DUAL SUPPLY¹($V_{DD} = +5 V \pm 10\%$, $V_{SS} = -5 V \pm 10\%$, GND = 0 V, unless otherwise noted.)

		Y Version -40°C	-40°C		
Parameter	25°C	to +85°C	to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range		Vs	s to V _{DD}	V	
On-Resistance (R _{ON})	85	0	0 22	Ω typ	$V_{S} = \pm 3 V, I_{S} = -1 mA$
	115	140	160	Ω max	Test Circuit 1
On-Resistance Match Between	2			Ω typ	
Channels (ΔR_{ON})	4	5.5	6.5	Ω max	$V_{S} = \pm 3 V, I_{S} = -1 mA$
On-Resistance Flatness (R _{FLAT(ON)})	25			Ω typ	$V_{s} = \pm 3 V, I_{s} = -1 mA$
	40	55	60	Ω max	
LEAKAGE CURRENTS					$V_{DD} = +5.5 V_{.} V_{cc} = -5.5 V_{.}$
Source OFF Leakage Is (OFF)	+0.01			nA typ	$V_{\rm D} = +4.5 \text{ V}, V_{\rm S} = \pm 4.5 \text{ V};$
bource off Leanage 13 (off)	+0.1	+0.25	+2	nA max	Test Circuit 2
Drain OFF Leakage In (OFF)	+0.01	_01_0		nA typ	$V_{\rm D} = +4.5 \text{ V}, V_{\rm S} = \pm 4.5 \text{ V};$
	± 0.1	± 0.25	± 2	nA max	Test Circuit 2
Channel ON Leakage ID, Is (ON)	± 0.01			nA tvp	$V_D = V_s = \pm 4.5 V$, Test Circuit 3
	±0.1	±0.25	±6	nA max	
DIGITAL INPUTS					
Input High Voltage, V _{INH}			2.4	V min	
Input Low Voltage, V _{INL}			0.8	V max	
Input Current					
I _{INI} or I _{INH}	0.005			μA typ	$V_{IN} = V_{INI}$ or V_{INH}
			± 0.1	µA max	
C _{IN} , Digital Input Capacitance	2			pF typ	
DYNAMIC CHARACTERISTICS ²					
t _{oN}	45			ns typ	$R_L = 300 \Omega, C_L = 35 pF$
	65	75	90	ns max	$V_s = 3.0 V$, Test Circuit 4
t _{OFF}	25			ns typ	$R_{L} = 300 \Omega, C_{L} = 35 pF$
	40	45	50	ns max	$V_{\rm S}$ = 3.0 V, Test Circuit 4
Break-Before-Make Time Delay, t _D	15			ns typ	$R_{L} = 300 \Omega, C_{L} = 35 pF$
			10	ns min	$V_{S1} = V_{S2} = 3.0 V$, Test Circuit 5
Charge Injection	-0.5			pC typ	$\mathbf{V}_{\mathrm{S}}=0\ \mathbf{V},\ \mathbf{R}_{\mathrm{S}}=0\ \mathbf{\Omega},$
					$C_L = 1 \text{ nF}$, Test Circuit 6
Off Isolation	-65			dB typ	$R_{L} = 50 \Omega, C_{L} = 5 pF,$
					f = 10 MHz, Test Circuit 7
Channel-to-Channel Crosstalk	-90			dB typ	$R_{\rm L} = 50 \ \Omega, \ C_{\rm L} = 5 \ pF,$
	(00)				f = 10 MHz, Test Circuit 8
-3 dB Bandwidth	680			MHz typ	$R_L = 50 \Omega$, $C_L = 5 pF$, Tost Circuit 0
$C_{c}(OFF)$	5			pF typ	f = 1 MHz
$C_{\rm P}$ (OFF)	5			nF typ	f = 1 MHz
$C_{\rm D}, C_{\rm S}(\rm ON)$	5			pF typ	f = 1 MHz
	-			r- 5r	
TOWER REQUIREMENTS	0.001				$v_{DD} = +0.5 \text{ V}, v_{SS} = -0.5 \text{ V}$
1 ^{DD}	0.001		1.0	μA typ	Digital inputs – U V Or 5.5 V
T	0.001		1.0		Digital Inputs = 0 V or 5 5 V
1 22	0.001		1.0		
			1.0	put max	

NOTES

¹Temperature range is as follows. Y Version: -40°C to +125°C.

²Guaranteed by design, not subject to production test.

Specifications subject to change without notice.

SINGLE SUPPLY¹ ($V_{DD} = 5 V \pm 10\%$, $V_{SS} = 0 V$, GND = 0 V, unless otherwise noted.)

Parameter	25°C	Y Version -40°C to +85°C	-40°C to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			0 V to V _{DD}	V	
On-Resistance (R_{ON})	210			Ω typ	$V_{s} = 3.5 V, I_{s} = -1 mA;$
	290	350	380	Ω max	Test Circuit 1
On-Resistance Match Between	3			Ω typ	$V_{\rm S} = 3.5 \text{ V}, I_{\rm S} = -1 \text{ mA}$
Channels (ΔR_{ON})	10	12	13	Ω max	
LEAKAGE CURRENTS					$V_{DD} = 5.5 V$
Source OFF Leakage I _S (OFF)	±0.01			nA typ	$V_{\rm S} = 1 \text{ V}/4.5 \text{ V}, V_{\rm D} = 4.5 \text{ V}/1 \text{ V};$
	±0.1	± 0.25	± 2	nA max	Test Circuit 2
Drain OFF Leakage I _D (OFF)	±0.01			nA typ	$V_{\rm S} = 1 \text{ V}/4.5 \text{ V}, V_{\rm D} = 4.5 \text{ V}/1 \text{ V};$
	±0.1	± 0.25	± 2	nA max	Test Circuit 2
Channel ON Leakage I_D , I_S (ON)	±0.01			nA typ	$V_{\rm S} = V_{\rm D} = 1$ V or 4.5 V, Test Circuit 3
	±0.1	±0.25	±6	nA max	
DIGITAL INPUTS					
Input High Voltage, V _{INH}			2.4	V min	
Input Low Voltage, V _{INL}			0.8	V max	
Input Current					
I _{INL} or I _{INH}	0.005			μA typ	$V_{IN} = V_{INL}$ or V_{INH}
			± 0.1	µA max	
C _{IN} , Digital Input Capacitance ²	2			pF typ	
DYNAMIC CHARACTERISTICS ²					
t _{ON}	70			ns typ	$R_{L} = 300 \Omega, C_{L} = 35 pF$
	100	130	150	ns max	$V_{\rm S}$ = 3.0 V, Test Circuit 4
t _{OFF}	25			ns typ	$R_L = 300 \Omega, C_L = 35 pF$
	40	45	50	ns max	$V_s = 3.0 V$, Test Circuit 4
Break-Before-Make Time Delay, t_D	25			ns typ	$R_L = 300 \Omega$, $C_L = 35 pF$
			10	ns min	$V_{S1} = V_{S2} = 3.0 \text{ V}$, Test Circuit 5
Charge Injection	1			pC typ	$V_{\rm S} = 0$ V, $R_{\rm S} = 0$ Ω , $C_{\rm L} = 1$ nF;
Off Inslation	60			dD true	$P = 500 C = 5 \pi E f = 10 MHz$
Oll Isolation	-02			ав тур	$R_L = 50 \Omega_2, C_L = 5 \text{ pr}, 1 = 10 \text{ MHz}$
Channel to Channel Crosstalk	00			dB twp	$P_{r} = 50.0 C_{r} = 5 \text{ pE} \text{ f} = 10 \text{ MHz}$
Chamici-to-Chamici Crosstaik	-90			ub typ	$R_{L} = 50.32$, $C_{L} = 5.01^{\circ}$, $T = 10.00112$ Test Circuit 8
-3 dB Bandwidth	680			MHz typ	$R_{I} = 50 \Omega, C_{I} = 5 pF$, Test Circuit 9
C _s (OFF)	5			pF typ	f = 1 MHz
C _D (OFF)	5			pF typ	f = 1 MHz
$C_{\rm D}, C_{\rm S}({\rm ON})$	5			pF typ	f = 1 MHz
POWER REQUIREMENTS					$V_{DD} = 5.5 V$
I _{DD}	0.001			μA typ	Digital Inputs = 0 V or 5.5 V
			1.0	μA max	-

NOTES

¹Temperature ranges are as follows. Y Version: -40°C to +125°C.

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Specifications subject to change without notice.

ADG611/ADG612/ADG613-SPECIFICATIONS

SINGLE SUPPLY¹ ($V_{DD} = 3 V \pm 10\%$, $V_{SS} = 0 V$, GND = 0 V, unless otherwise noted.)

		Y Version -40°C	-40°C		
Parameter	25°C	to +85°C	to +125°C	Unit	Test Conditions/Comments
ANALOG SWITCH					
Analog Signal Range			0 V to V_{DD}	V	
On-Resistance (R _{ON})	380	420	460	Ω typ	$V_S = 1.5 V$, $I_S = -1 mA$; Test Circuit 1
LEAKAGE CURRENTS					$V_{DD} = 3.3 V$
Source OFF Leakage I _S (OFF)	$\pm 0.01 \\ \pm 0.1$	±0.25	±2	nA typ nA max	$V_{S} = 1 \text{ V/3 V}, V_{D} = 3 \text{ V/1 V};$ Test Circuit 2
Drain OFF Leakage I _D (OFF)	±0.01			nA typ	$V_{\rm S} = 1 \text{ V}/3 \text{ V}, V_{\rm D} = 3 \text{ V}/1 \text{ V};$
	±0.1	± 0.25	± 2	nA max	Test Circuit 2
Channel ON Leakage I _D , I _S (ON)	±0.01			nA typ	$V_{\rm S} = V_{\rm D} = 1$ V or 3 V, Test Circuit 3
	±0.1	±0.25	±6	nA max	
DIGITAL INPUTS					
Input High Voltage, V _{INH}			2.0	V min	
Input Low Voltage, V _{INL}			0.8	V max	
Input Current	0.005				V - V or V
I _{INL} or I _{INH}	0.005		+0.1	μΑ typ	$v_{\rm IN} - v_{\rm INL}$ or $v_{\rm INH}$
C _{IN} , Digital Input Capacitance	2		±0.1	pF typ	
DYNAMIC CHARACTERISTICS ²					
t _{ON}	130			ns typ	$R_{\rm L} = 300 \Omega, C_{\rm L} = 35 \rm pF$
	185	230	260	ns max	$V_{\rm S} = 2 \text{ V}$, Test Circuit 4
t _{OFF}	40			ns typ	$R_L = 300 \Omega, C_L = 35 pF$
	55	60	65	ns max	$V_s = 2 V$, Test Circuit 4
Break-Before-Make Time Delay, t _D	50			ns typ	$R_{L} = 300 \Omega, C_{L} = 35 pF$
			10	ns min	$V_{S1} = V_{S2} = 2 V$, Test Circuit 5
Charge Injection	1.5			pC typ	$V_{\rm S} = 0$ V, $R_{\rm S} = 0$ Ω , $C_{\rm L} = 1$ nF; Test Circuit 6
Off Isolation	-62			dB typ	$R_L = 50 \Omega$, $C_L = 5 pF$, $f = 10 MHz$ Test Circuit 7
Channel-to-Channel Crosstalk	-90			dB typ	$R_L = 50 \Omega$, $C_L = 5 pF$, $f = 10 MHz$ Test Circuit 8
-3 dB Bandwidth	680			MHz typ	$R_L = 50 \Omega$, $C_L = 5 pF$, Test Circuit 9
C _s (OFF)	5			pF typ	f = 1 MHz
C _D (OFF)	5			pF typ	f = 1 MHz
$C_D, C_S(ON)$	5			pF typ	f = 1 MHz
POWER REQUIREMENTS					$V_{DD} = 3.3 V$
I _{DD}	0.001			μA typ	Digital Inputs = 0 V or 3.3 V
			1.0	μA max	

NOTES ¹Temperature ranges are as follows. Y Version: -40°C to +125°C.

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Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS¹

$(T_A = 25^{\circ}C \text{ unless otherwise noted})$
V_{DD} to V_{SS}
V_{DD} to GND $\hfill {\rm Constant}$
V_{SS} to GND \ldots
Analog Inputs ² V_{SS} – 0.3 V to V_{DD} + 0.3 V
Digital Inputs ² GND – 0.3 V to V_{DD} + 0.3 V
or 30 mA, Whichever Occurs First
Peak Current, S or D 20 mA
(Pulsed at 1 ms, 10% Duty Cycle max)
Continuous Current, S or D 10 mA
3 V operation 85°C to 125°C 7.5 mA
Operating Temperature Range
Automotive (Y Version)40°C to +125°C

 Storage Temperature Range
 -65° C to $+150^{\circ}$ C

 Junction Temperature
 150° C

 16-Lead TSSOP, θ_{JA} Thermal Impedance
 150.4° C/W

 Lead Temperature, Soldering
 Vapor Phase (60 sec)

 Vapor Phase (60 sec)
 215° C

 Infrared (15 sec)
 220° C

 NOTES
 ¹Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only: functional operation of the

nent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Only one absolute maximum rating may be applied at any one time.

²Overvoltages at IN, S, or D will be clamped by internal diodes. Current should be limited to the maximum ratings given.

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
ADG611YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG612YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16
ADG613YRU	-40°C to +125°C	Thin Shrink Small Outline Package (TSSOP)	RU-16

Table I. ADG611/ADG612 Truth Table

ADG611 In	ADG612 In	Switch Condition
0	1	ON
1	0	OFF

Table II. ADG613 Truth Table

Logic	Switch 1, 4	Switch 2, 3
0	OFF	ON
1	ON	OFF

PIN CONFIGURATIONS



CAUTION_

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADG611/ADG612/ADG613 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



TERMINOLOGY

V _{DD}	Most Positive Power Supply Potential
V _{SS}	Most Negative Power Supply Potential
I _{DD}	Positive Supply Current
I _{SS}	Negative Supply Current
GND	Ground (0 V) Reference
S	Source Terminal. May be an input or output
D	Drain Terminal. May be an input or output
IN	Logic Control Input
$V_D(V_S)$	Analog Voltage on Terminals D, S
R _{ON}	Ohmic Resistance between D and S
$\Delta R_{\rm ON}$	On Resistance match between any two channels, i.e., R _{ONMAX} – R _{ONMIN} .
R _{FLAT(ON)}	Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal range.
I _S (OFF)	Source Leakage Current with the Switch "OFF"
I _D (OFF)	Drain Leakage Current with the Switch "OFF"
I_D , I_S (ON)	Channel Leakage Current with the Switch "ON"
V _{INL}	Maximum Input Voltage for Logic "0"
V _{INH}	Minimum Input Voltage for Logic "1"
$I_{\rm INL}(I_{\rm INH})$	Input Current of the Digital Input.
C _S (OFF)	"OFF" Switch Source Capacitance. Measured with reference to ground.
C _D (OFF)	"OFF" Switch Drain Capacitance. Measured with reference to ground.
$C_D, C_S(ON)$	"ON" Switch Capacitance. Measured with reference to ground.
C _{IN}	Digital Input Capacitance
t _{ON}	Delay between applying the digital control input and the output switching on. See Test Circuit 4.
t _{OFF}	Delay between applying the digital control input and the output switching off.
Charge Injection	A measure of the glitch impulse transferred from the digital input to the analog output during switching.
Off Isolation	A measure of unwanted signal coupling through an "OFF" switch.
Crosstalk	A measure of unwanted signal that is coupled through from one channel to another as a result of parasitic capacitance.
On Response	Frequency Response of the "ON" Switch
Insertion Loss	Loss Due to the ON Resistance of the Switch

Typical Performance Characteristics-ADG611/ADG612/ADG613



TPC 1. On Resistance vs. $V_D(V_S)$, Dual Supply



TPC 2. On Resistance vs. $V_D(V_S)$, Single Supply



TPC 3. On Resistance vs. $V_D(V_S)$ for Different Temperatures, Dual Supply



TPC 4. On Resistance vs. $V_D(V_S)$ for Different Temperatures, Single Supply



TPC 7. Charge Injection vs. Source Voltage



TPC 5. Leakage Currents vs. Temperature, Dual Supply



TPC 8. t_{ON}/t_{OFF} Times vs. Temperature



TPC 6. Leakage Currents vs. Temperature, Single Supply



TPC 9. On Response vs. Frequency



TPC 10. Off Isolation vs. Frequency



TPC 11. Crosstalk vs. Frequency

APPLICATIONS

Figure 1 illustrates a photodetector circuit with programmable gain. With the resistor values shown in the circuits, and using different combinations of switches, gains in the range of 2 to 16 can be achieved.



Figure 1. Photodetector Circuit with Programmable Gain

Test Circuits



Test Circuit 1. On Resistance





Test Circuit 2. Off Leakage

Test Circuit 3. On Leakage



Test Circuit 4. Switching Times



Test Circuit 5. Break-Before-Make Time Delay



Test Circuit 6. Charge Injection



Test Circuit 7. Off Isolation



Test Circuit 8. Channel-to-Channel Crosstalk



Test Circuit 9. Bandwidth

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OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

